

ENHANCING VALUE AND USE OF AGRICULTURAL AND FOREST PRODUCTS

The Enhancing Value and Use of Agricultural and Forest Products Division responds to the growing need to enhance the competitive value and quality of U.S. agricultural and forest products. Research in this area builds the scientific base of knowledge to use agricultural and forest materials more fully and effectively. The Division supports both fundamental and applied research on new and improved processes and on development of new uses for agricultural and forest materials. Program Areas in this Division include: Value-Added Products Research encompassing Food and Non-Food Characterization/Process/Product Research, and Improved Utilization of Wood and Wood Fiber.

FOOD CHARACTERIZATION/PROCESS/PRODUCT RESEARCH

Panel Manager - Dr. Shelly J. Schmidt, University of Illinois

Program Director - Mr. Jeffery L. Conrad

This program area seeks to better understand the properties (physical, chemical and biological) of raw agricultural materials and products related to their quality and processing characteristics and to develop innovative products and processes for better utilization and more efficient conversion of agricultural materials to higher value food products. Specifically, research is supported on value-added food products which contribute to expanded markets for agricultural commodities, lower-cost food products, and a more competitive domestic food industry with expanded export opportunities. This program supports research to increase the quality, utility, convenience, nutrient value, and safety of food products through innovative processing methods. Research providing the basis for development of new food products is also supported.

9701560 Quality, Safety Monitoring and Fault Diagnosis in Multivariable Food Processing
Cinar, A.; Balasubramaniam, V.M.
Grant 97-35503-4887
Illinois Institute of Technology
Chemical and Environmental Engineering Department
Chicago, IL 60616-3793
Strengthening Award
\$160,000
3 Years

In the growing markets for value-added food products, the quality, nutrient value, and safety of products have an important contribution in the worldwide competitiveness of U. S. agricultural and food products. For most quality and safety variables, sensors that can make direct measurements during the food processing operation are not available. Statistical process monitoring, quality control, and fault diagnosis methods provide a low-cost high-return alternative solution for maintaining high product quality and safety, and reducing quality variations. The objective of the proposed research is to develop new process monitoring, fault diagnosis and supervision techniques for food processes based on multivariate statistical theory, system theory, and artificial intelligence tools. The goal is to develop fast and accurate methods for monitoring product quality and safety, diagnosing source causes for manufacturing inferior quality or unsafe products, supervising process information assessment, and providing useful refined information to plant personnel for implementing timely corrective action. Multivariable process monitoring tools will be based on canonical variate state space modeling, principal components analysis, and projection to latent structures techniques. Fault diagnosis methods will rely on pattern recognition techniques such as hidden Markov models and time warping and on artificial intelligence tools. Supervisory information assessment and suggestions for corrective action will be carried out by a real-time knowledge-based system developed in G2 software environment. The methodology developed will be tested with two food processing operations, a high-temperature short-time (HTST) dairy pasteurization system and a fully cooked breakfast sausage process. The work will be carried out in collaboration with National Center for Food Safety and Technology (NCFST), regulatory agency, and industry. The HTST pasteurization system is a pilot plant scale unit located at the NCFST. The breakfast sausage process is a commercial production line, and data from this process will be used without interfering with process operation. The methodology and software developed would be useful in many other food processes, benefitting the food processing industries.

9701672 Prediction of Dried Food Quality
Okos, M.
Grant 97-35503-4409
Purdue University
Department of Agricultural and Biological Engineering
West Lafayette, IN 47907-1146
\$195,000
3 Years

Drying of food and agricultural products is a widely applied process, not only to increase shelf-life, reduce packaging costs, lower shipping weights, and maintain nutritional value, but also to obtain the 'right' texture - a quality characteristic of the product that changes significantly depending on ingredient and process conditions. Different drying processes and variations in ingredient sources play an important role in final product quality texture. The market for dried food would be expanded greatly if one could quantitatively predict the process conditions and ingredients needed to produce a desired product attribute.

The goal of this study is to develop a method that will help define the interrelationship between product quality and drying process conditions for food products based on ingredient composition and properties. Current research in our laboratory has successfully predicted shrinkage and drying profiles of starch-gluten gels such as pasta and other high density products. The current work will be extended to low density porous and expanded products. The proposed extension would involve three steps: extension of the drying model to account for vapor flow and for expansion; development of property models for fundamental properties as a function of moisture and temperature; and application of the property models to predict final product density, porosity, and thickness of the 'crust'. Extruded starch-gluten mixtures will be employed as a model food system.

The proposed work can eventually be used not only in the design and optimal control of drying and baking processes, but also in product development. The decision to choose one drying process and a set of ingredients over another currently requires considerable trial and error. By integrating product development decisions with process design considerations, this work will provide the basis to help optimize and effectively control drying processes to obtain higher quality products. This research will be useful to food and agricultural product processors for a variety of operations such as drying, extrusion, baking, and toasting.

9701687 Factors Contributing to the Association of 2-Pentyl Pyridine with Soy Proteins**Boatright, W.L.****Grant 97-35503-4529****University of Kentucky****Department of Animal Sciences****Lexington, KY 40546-0215****\$135,000****2 Years**

The flavor of soy protein products (often described as beany, intensely bitter, biting and throat-catching) has been the single greatest technical impediment to their increased usage in human foods. Understanding the types of components contributing these undesirable flavors and preventing their occurrence will add substantial value to the U. S. soybean crop.

Using gas chromatography (GC)/olfaction combined with GC/mass spectroscopy, we have demonstrated for the first time that 2-pentyl pyridine is a major odor compound associated with soy protein isolates (SPI). Subsequent sensory analyses have further demonstrated that the level of

2-pentyl pyridine found in SPI (typically 0.65 ppm) combined with its repulsive flavor profile (described as throat-catching and grassy in water) and extremely low flavor threshold level (0.000012 ppm) makes it a major contributor to the undesirable flavor of SPI. (i.e., its mean content in SPI is 54,000 times greater than its flavor threshold). Other compounds that had previously been assumed to contribute to the flavor of soy products (e.g., hexanal and 2-pentyl furan) were shown to make relatively minor contributions. This project is designed to contribute technology that will lead to a reduction in the level of 2-pentyl pyridine associated with soy protein isolates and subsequently improve the flavor of these products. This will be done by performing a systematic evaluation of the occurrence of 2-pentyl pyridine in various soybean varieties (and protein isolates prepared from these soybeans), elucidating the biochemical mechanism leading to the formation of 2-pentyl pyridine, and determining the binding characteristics of 2-pentyl pyridine to soy proteins.

9701487 Regulation of C₆-Aldehyde and Alcohol Formation in Plant Tissues**Hildebrand, D.F.****Grant 97-35503-4367****University of Kentucky****Agronomy Department****Lexington, KY 40546-0091****\$129,563****2 Years**

This research will investigate the control of the formation of C₆-aldehydes and alcohols in plant tissues. C₆-aldehydes and alcohols and derivatives are important in the flavor and aroma of many food and beverage products, and there is interest in the food industry for more effective natural production of these molecules. These molecules also show potential for treating foods and food handling utensils for reducing food borne illnesses. These compounds are formed from linoleic and linolenic acids, common fatty acids in plant tissues. Their production in many plant tissues is greatly enhanced by tissue damage or wounding. The formation of C₆-aldehydes and alcohols will be examined in different plant tissues chosen for their wide differences in formation of C₆-aldehydes, alcohols and related metabolites. Radiolabeled linoleic and linolenic acids and a precursor will be fed to selected plant tissues in several forms to facilitate uptake and metabolism. The time-course of the metabolism of these precursors into the various intermediate and final products will be examined to determine the key regulatory steps governing the conversion of linoleic and linolenic acids into C₆-aldehydes and alcohols. The effects of tissue damage by mechanical damage or wounding and freezing/thawing on the production of C₆-aldehydes and alcohols will also be investigated similarly. The information acquired from this research will be used for the selection of the best plant tissues or tissue combinations and conditions for potential industrial production of natural C₆-aldehydes and alcohols for use in food quality improvement and enhancement of food and food ingredient export.

9701691 Analysis of the Role of Blood in Quality Deterioration of Fish and its Prevention**Hultin, H.O.****Grant 97-35503-4531****University of Massachusetts****Department of Food Science****Amherst, MA 01003-6010****\$145,000****3 Years**

It is recognized that there are quality problems with muscle foods contaminated with blood. Little is known as to how blood left in the tissue contributes to quality loss in fish meat. The potential for spoilage by lipid oxidation is high due to the unstable nature of the lipids in fish blood, the rapid coagulation of fish blood after death which prevents its removal, and the practical

difficulties of bleeding many fish species due to their small size, low value, and methods of capture. The production of cultured fish offers a good opportunity for removing blood from the product since harvesting and processing can be fully controlled. It is not known, however, how much blood has to be removed for a given product quality. Rainbow trout will be used in this study. The goals of this project are to understand the role of blood in fish quality and shelf life and to develop techniques that will reduce the deleterious effects of blood. The first goal will be achieved by isolating fish blood from live (anaesthetized) fish. Both whole blood and its major fractions, red and white blood cells and plasma, will be tested for their quality-reducing properties. The isolated blood or its separated components will be tested by adding to fish muscle tissues. Techniques to reduce undesirable effects will include improved methods of bleeding and measurement of retained blood and the use of antioxidants to prevent lipid oxidation.

9701494 Non-Destructive Characterization Of Food Emulsions Using Ultrasound
McClements, D.J.

Grant 97-35503-4371

University of Massachusetts
Department of Food Science
Amherst, MA 01003-1410

\$125,000
3 Years

Many value-added foods consist either partly or wholly as emulsions, or have been in an emulsified state sometime during their production, e.g., milk, cream, butter, margarine, mayonnaise, soup, sauces, cream-liqueurs, coffee whitener, deserts, salad cream and ice-cream. Improvement in the quality of these products depends on the availability of analytical techniques to characterize their properties. Analytical techniques are required for fundamental studies, such as quality control and improving our understanding of the factors that determine emulsion properties, so that emulsion properties can be monitored and controlled during manufacture and storage.

The objective of this proposal is to develop an ultrasonic imaging device for characterizing the properties and stability of food emulsions. Ultrasound has major advantages over traditional methods because it is nondestructive, capable of rapid and precise measurements, and can be used to analyze optically opaque and concentrated emulsions *in situ*. The device will be tested by monitoring the stability of well characterized model emulsions, as well as a number of real food emulsions (cream liqueur and salad dressing).

The development and application of an ultrasonic imaging device for characterizing food emulsions would have considerable benefits for the U. S. economy. The device could be used as an analytical instrument to elucidate the key factors that determine emulsion stability, or it could be used as a quality control instrument to predict the shelf-life of food emulsions. The device would, therefore, lead to the design of foods with improved quality and more efficient manufacturing operations.

9701538 Relation of Myoglobin Structure and Prooxidant Activities to Fish Meat Quality
Cashon, R.E.

Grant 97-35503-4927

University of Maine
Department of Biochemistry, Microbiology, and Molecular Biology
Orono, ME 04469-5735

Strengthening Award
\$143,432
3 Years

The pigments most responsible for the bright red surface color of fish meat are oxymyoglobin and oxyhemoglobin. Changes in the coloration of both unprocessed and processed fish meat are largely due to oxidative and chemical changes in the myoglobin content. Further, myoglobin is known to interact with other components, particularly lipids, enhancing oxidative processes. Few, if any, comprehensive structure/function studies have been published comparing the myoglobins of fish species of commercial significance. Our proposed research will address this deficiency through four explicit objectives: (1) determine the primary protein sequences of a selected group of teleost fish myoglobins using PCR amplification, cDNA cloning and sequencing; (2) characterize the purified myoglobin from each of the selected fish species with respect to protein stability and prooxidant potential; (3) correlate the structural and functional data into meaningful model(s) to identify individual residues and features important to myoglobin structure and prooxidant properties; (4) integrate the biochemical/structural findings into models which describe (a) the relationship of myoglobin oxidation and meat quality in a wide variety of fish species and (b) strategies to try to intervene in the oxidation process where possible. Successful completion of these 4 objectives will provide a comprehensive basic scientific understanding of the relationship between fish myoglobin structure and its inherent peroxidase-like activity. This information is of direct relevance to both the seafood and aquaculture industries.

9701117 Biochemical Characterization of Pale, Soft Exudative Turkey
Strasburg, G.M.; Linz, J.E.**Grant 97-35503-4372****Michigan State University**
Department of Food Science and Human Nutrition
East Lansing, MI 48824-1224**\$250,000**
3 Years

Pale, soft, exudative (PSE) meat costs the turkey industry at least \$30 million per year due to reduced protein functionality in turkey products. Research on PSE pork identified a genetic mutation in the skeletal muscle calcium channel that predisposes hogs to develop PSE pork. Testing for the presence of this PSE allele in hogs allowed breeders to control the frequency of this mutation and reduce monetary losses associated with PSE pork. Studies on PSE turkey suggest a similar biochemical basis as in PSE pork, increased postmortem muscle metabolism associated with abnormal activity of the skeletal muscle calcium channel. This project is designed to correlate skeletal muscle calcium channel activity with PSE turkey. Cosegregation between PSE turkey and abnormal calcium channel activity will define the biochemical basis of PSE turkey and suggest several candidate genes that underlie its genetic basis. Initial efforts will be focused on sequencing a cDNA fragment homologous to the region of the PSE allele in hogs. If a homologous mutation is not identified, other regions of calcium channel cDNA that contain mutations associated with biochemical defects in human skeletal muscle will be sequenced and compared. Other proteins associated with calcium channel activity will be studied if PSE turkey is not associated with a mutation(s) in the calcium channel. Identification of a genetic mutation(s) that predisposes turkeys to the development of PSE meat will lead to a molecular test to control its frequency in turkeys and reduce monetary losses associated with PSE meat in the turkey industry.

9701486 Improved Lactococcal Phage Defenses for More Consistent Dairy Fermentations
O'Sullivan, D.J.; Twomey, D.P.; McKay, L.L.**Grant 97-35503-4445****University of Minnesota, Twin-Cities**
Department of Food Science and Nutrition
St. Paul, MN 55108**\$200,000**
3 Years

Since the first U.S. cheese factory in 1851, the cheese industry has progressively grown into a multi-billion dollar industry. The capacity for this growth can largely be attributed to technological advances in the cheese production industry. The most delicate step in the cheese manufacturing process has always been the reliance on a bacterial culture to start the process. This culture is typically referred to as the 'starter culture' and in many cases consists primarily of *Lactococcus lactis*. Rapid killing of these bacteria by phage (bacterial viruses) was first recognized in the 1930's and to this day, remains a major cause of reduced or failed starter activities, resulting in products of low quality or of public health significance. Improving the resistance of starter cultures to phage is one, if not the, greatest need of this industry. Some starter strains, however, were known to be more resilient to phages than other strains and in the 1970's, this was shown to be due to natural defense mechanisms encoded by mobile plasmid elements (circular pieces of DNA separate from the chromosome) within these strains. By transferring these plasmids to other starter strains, the cheese industry was able to improve the resistance of its starter bacteria to attack by prevalent phages in the cheese making environment. However, phages are still problematic. To improve the effectiveness of native phage defenses, and consequently improve the efficiency and reliability of fermentations, it is necessary to understand how the defenses operate and how their expression is regulated within the starter bacteria. This will enable a directed strategy for combining defenses in a single cell, which target different steps in the phage developmental cycle. Understanding how the expression of the defenses is regulated in lactococci will enable accurate prediction of the effectiveness of the defenses during all stages of the fermentation process. In this study, we propose to further our investigation into a novel abortive phage infection (Abi) system encoded by a native plasmid from a lactococcal starter bacterium. We propose to complete the molecular characterization of the genetic loci required for its expression and to study how and when its expression is regulated within the lactococcal cell. In summary, these studies will further the field of phage defenses in commercial lactococcal starter bacteria, which is a prerequisite if more reliable starter bacteria are to be developed for milk fermentations.

9701730 Flavor Impact of Fat and Fat Replacers on Lower Fat Chocolate Ice Creams
Marshall, R.T.; Gruen, I.; Heymann, H.**Grant 97-35503-4491****University of Missouri**
Department of Food Science and Human Nutrition
Columbia, MO 65211**\$115,000**
2 Years

This research is directed at the national goal of enhancing values of agricultural products through quantification of quality and modification of formulas. Milk fat and cocoa butter, common ingredients of full-fat ice creams are being replaced with fat substitutes in new varieties of ice cream. The effects of this reduction in fat content on flavor and texture of chocolate ice creams are unknown. Fat replacers may introduce unfavorable reactions with chocolate flavors or may not provide enough of the flavor-enhancing qualities of milk fat. The objectives of this research are to determine (1) the relative effects of cocoa butter and

milk fat, (2) the effects of varying the concentrations of milk fat through all of the potential label concentrations, and (3) the effects of several commercially available fat replacers on the sensory, chemical and physical characteristics of chocolate ice creams. Sensory tests will be done with trained panel members who will use approved methods of describing flavor and texture and will assign quantitative values to the sensory characteristics of the various products. Consumer ratings will also be done. Highly sensitive methods (gas chromatography and mass spectrometry) will be used to identify volatile flavor components, and results of taste tests will be linked to results of chemical analyses using powerful statistical methods. Physical properties to be measured include viscosities of mixes plus rates of melting, hardness, and smoothness of finished ice creams.

9701727 Nondestructive Monitoring of Hybrid Corn Possessing Genetically Modified Starch
Campbell, M.R.

Grant 97-35503-4753

Truman State University
Division of Science
Kirksville, MO 63501-4221

New Investigator/Strengthening Award
\$61,894
2 Years

Most corn in the United States is used as animal feed, however, in recent years an increasing amount has been refined in order to produce various food and nonfood products. Starch, a major product from corn refining, is a raw ingredient for manufacturing many of these. Some examples include corn sweeteners, biodegradable packing materials, fuel ethanol and modified starches used in processed foods. Corn farmers in the United States directly benefit from these uses because it increases the demand for corn and the profitability of farming. To further expand the use of corn, scientists have developed hybrids with genetically modified starch. In the food industry there are several advantages in using these. For example, they do not require regulatory approval and they have fewer problems associated with consumer acceptance since they are "all natural." As the acreage of genetically modified starch hybrids increases, a major obstacle limiting their availability to industrial processors is keeping it separated from normal corn during grain transportation and storage. Those involved in handling grain would greatly benefit from a method to monitor the purity and avoid contamination. The objective of this research is to provide the grain industry with a rapid, non-destructive method to test the purity of these hybrids. We plan to investigate the use of Near-Infrared Transmittance Spectroscopy (NITS). Using numerous corn varieties we will try to calibrate the instrument so it will "recognize" hybrids with genetically different starch. Many elevators and grain processing facilities currently have NITS instruments in operation for routine testing of protein, starch and oil content. If the NITS instrument can be calibrated for starch quality characteristics from our research, instruments used in industrial settings could simply load our calibration with minimal additional expense or training.

9701674 Triggered Suicide Systems for Bacteriophage Defense and Gene Containment
Klaenhammer, T.R.

Grant 97-35503-4368

North Carolina State University
Department of Food Science
Raleigh, NC 27695-7624

\$210,000
3 Years

Bacteria drive many industrial fermentations that produce food products (cheese, wine, sausage, pickles, crackers, soy sauce), organic chemicals, and medical drugs via biotechnology (insulin, growth hormone). Bioprocessing bacteria are becoming more specialized and are expected to perform continuously in highly efficient and valuable fermentations. However, viruses which attack bacteria (termed bacteriophages) routinely appear in fermentation plants. Once present, the bacteriophages multiply faster and eventually kill the culture and fermentation. The end result is compromised quality, safety, or product loss. Most phage protection strategies rely on good sanitation and aseptic handling practices. Such practices are effective to a point, but new viruses continue to appear. This study intends to improve a biological trap which has been designed to capture and destroy phage after they first appear in the fermentation environment. Using recombinant DNA technologies, we have created a trap inside the bacterium that recognizes an infection by a bacteriophage. The trap contains a specific trigger that is fired only after the phage enters the bacteria. The trigger then explodes a suicide system killing the incoming phage as well as the infected bacterium. This altruistic sacrifice for one infected cell prevents the phages from infecting other cells (>1 billion/ml) in the fermentation. The phage-trapping strategy acts like a biological sentry which constantly halts the proliferation of new bacterial viruses in fermentation. This study will attempt to expand the potential industrial applications of this strategy by seeking a broader range of phage-induced triggers and employing more effective suicide genes in the trap.

9701682 Characterization of Granule-Bound Starch Synthase Isoforms of Oat
Graybosch, R.A.; Peterson, C.J.**Grant 97-35503-4492****USDA Agricultural Research Service**
University of Nebraska
Lincoln, NE 68583-0937**\$107,879**
2 Years

Starch is a complex molecule produced in plant storage organs such as tubers and seed. Starch comprises a significant portion of human diets. Starch is formed by the polymerization of glucose (a simple sugar) units. Two types of polymers, amylose and amylopectin, are found in starch grains. Amylose consists of unbranched chains of glucose, while in amylopectin, both straight and branched glucose chains are found. Amylose is synthesized through the activity of an enzyme known as the granule bound starch synthase. In oats, multiple forms (isoforms) of this enzyme exist. These isoforms are the products of at least three oat genes. In addition, multiple alleles appear to occur at each genetic locus. This project will assign the isoforms to genetic loci, will characterize each isoform in terms of its effects on amylose/amylopectin contents, and will determine whether amylose content can be altered, or eliminated, by changing the number of active genes. This project also will measure interactions between genetic background, granule bound starch synthase isoforms, and environmental factors, in the determination of oat starch amylose content. The ultimate goal is the production of a number of oat lines with variable, and defined, amylose contents. The ratio of amylose to amylopectin has direct consequences on the functionality of starch in many commercial food applications. Reducing the amounts of amylose in oat starch can alter water binding and cooking properties, and increase shelf life of oat products. The production of amylose-free starch could lead to new industrial applications and expanded demand for oats.

9701816 Detecting Internal Insect Infestation in Wheat by Near-Infrared Spectroscopy
Wehling, R.L.**Grant 97-35503-4530****University of Nebraska**
Department of Food Science and Technology
Lincoln, NE 68583-0919**\$59,627**
2 Years

Insect infestation in stored grain can result in serious economic losses and contamination of products made from the grain. The most serious infestations of stored products occur when insects hatch and develop inside the kernels of grain, allowing high infestation levels to occur without visible external signs. Existing methods for detecting internally infesting insects are either too unreliable or too time consuming to be incorporated successfully into the U.S. grain inspection system. Preliminary work in our laboratory has shown that single-kernel near-infrared (NIR) spectroscopy can rapidly and reliably identify kernels of wheat internally infested with granary weevil larvae. The objectives of this project include the development of methods for handling NIR spectral data that will permit the use of relatively simple and inexpensive NIR instruments to detect internal insect infestation. Secondly, the NIR technique will be tested for its ability to detect all three of the major internally infesting insect species that damage stored wheat, and will be evaluated to determine the earliest stage of insect development that can be identified. Finally, the effects of variations in wheat kernel hardness and class on the ability of the NIR technique to correctly identify infested kernels will be assessed, and methods developed to minimize errors due to hardness variations. If simple, rapid, and reliable NIR techniques can be developed that detect early stages of internal insect infestation in wheat, they would be applicable to the existing U.S. grain inspection system for detecting infested grain in commerce, and could also be used by grain processors to detect infested wheat and prevent it from being processed into contaminated products.

9701640 Enhancement of Soy Meal: High Temperature Enzymic Removal of Flatulence Factors
Eveleigh, D.E.; Chassy, B.M.**Grant 97-35503-4557****Rutgers University**
Department of Biochemistry & Microbiology
New Brunswick, NJ 08903-0231**\$130,000**
2 Years

Soy beans are a major U.S. crop. However, soy protein contains antinutritional factors, small oligosaccharides that produce severe flatulence in animals and humans, and additionally a protease inhibitor that restricts digestion. These factors limit the use of soy in foods soy milks a maximum of 25% is allowed in animal feed. Currently, the protease inhibitor is destroyed through a heat step during processing, and the flatulence factors, sugar oligosaccharide stachyose and raffinose, are partially removed by alcohol extraction. V-galactosidases hydrolyze the galactose moieties of the flatulence oligosaccharide to yield readily digestible products. We propose to use a heat stable V-galactosidase from the caldophile, *Thermotoga neapolitans*, a bacterium from the high temperature ocean vents that was isolated through culture at 80°C. It is proposed to integrate its highly active and heat stable V-galactosidase in the heating stage of industrial soy processing, thus combining destruction of the protease inhibitor with the removal of the flatulence factors in the single pre-existing heat treatment step. The proposal also addresses novel selective techniques for the isolation of V-galactosidase mutants through combined expression of fusion proteins containing the V-galactosidase and the green fluorescent protein, a marker protein of major current interest. The proposal addresses a major

food processing concern of flatulence associated with the feeding of leguminous products through removal of such antinutritional factors from soy products.

9701539 Flavor Sensors for Food Quality Control Based on Selective Polymer Films

Pedersen, H.; Henrikson, F.W.

Grant 97-35503-4490

Rutgers University

Department of Chemical and Biochemical Engineering

Piscataway, NJ 08855-0909

\$180,000

3 Years

The control of food quality is important in order to deliver a safe, consistent product with stringent specifications and to ultimately promote better nutrition and health. Flavors are widely recognized as components of food quality that greatly affect consumer acceptance, but the monitoring of flavor components in a process environment has been a difficult challenge. In particular, continuous at-line monitoring of food aroma during critical roasting, brewing and baking operations is rarely done in a way that key, individual flavor constituents are quantitatively measured. Empirical approaches are adopted instead. Sensing and control of food processing operations has been investigated at the Center for Advanced Food Technology (CAFT, Rutgers, The State University of New Jersey) for the past decade. This project builds on prior CAFT research efforts into monitoring and control during processing operations. We are planning on using novel approaches that rely on molecular recognition of individual flavor components by attempting to design target-molecule-specific interactions. The unique aspect of our approach is that the target compound dictates its own self-assembled interaction by using molecular imprinting of polymeric films that are subsequently used as a coating on an optical sensor. While the sensor coatings are unique to each individual flavor compound, the underlying coating is otherwise the same for all target compounds. A single sensor is made as specific as possible for a target flavor compound and, in either a single sensor or in an arrayed configuration, this is expected to yield the greatest possible discrimination among flavor profiles.

9701676 Chemical Basis of Crust Formation in Deep-fried Potatoes

Blumenthal, M.M.; Schaich, K.M.

Grant 97-35503-4600

Libra Technologies, Inc.

R/D/E

Metuchen, NJ 08840-1847

\$110,000

2 Years

At \$75 billion/year, the United States frying industry is huge. To cook high quality food, the frying oil must contain some, but not an excess of degradation products. Small amounts of polar breakdown products in oil form from contact with heat, water and oxygen. Some polar products help crust and flavor to form, while too large an amount of polars are possibly toxic and cause oil soakage, off flavor and limp or dried out crusts. Excess oil, and large amounts of frying oil polar materials are caloric and public health concerns in foods so widely consumed as French fried potatoes, for example.

In this research, the interactions arising between the cooking food and the oil under actual, restaurant-scale conditions are to be analyzed and described. Microscopic techniques from biotechnology and agriculture, image analysis derived from the space program, and texture and sensory analysis from food science are being combined to understand how the polar materials in frying oil interact with potato cell components to form an ideal crust on French fried Russet Burbank potatoes.

Potato growers, fried food producers, restaurant operators, and the public will benefit from knowledge guiding choice of potato variety, selection of optimal oil and frying conditions, and reduction of toxic or unpleasant polar materials in frying oils used to produce crusts on fried foods. A further benefit may be suggestions on possible ways to generate crusts without frying, thereby reducing the fat content of fried potatoes.

9701503 Role of Granule Size and Viscometer Geometry in Rheology of Starch Dispersions

Rao, M.A.; Walker, L.P.

Grant 97-35503-4493

Cornell University, Geneva

Department of Food Science and Technology

Geneva, NY 14456-0462

\$150,000

3 Years

Starch is a major source of energy in human diet and also a very important food ingredient for increasing viscosity of liquid foods or creating edible gels. Aqueous starch dispersions must be heated (gelatinization) to sufficiently high temperatures for creation of edible structures. During gelatinization, the raw starch granules absorb water and expand so that understanding change in granule size and expansion phenomenon should help in creation of foods with desirable structures. Raw granule size depends on the botanical source of starches (e.g., corn, wheat, rice, tapioca) and chemical modification, such as cross-linking. In addition to the botanical source, granule size of gelatinized starch dispersions also depends on the heating conditions (e.g., magnitude of maximum temperature, rate of heating, and shearing conditions) and presence of other components (e.g., sugars,

fats). Granule size and size distribution of several starches heated under different conditions will be examined using a particle size analyzer based on laser diffraction.

With many starches, granule rupture occurs when the starches are subjected to either prolonged heating or very high temperature conditions often encountered in food processing. Therefore, based on granule size data, an index of starch granule rupture will be developed. The edible structures often simultaneously exhibit characteristics of a liquid (viscous) and a solid (elastic), so that they are viscoelastic materials. Viscoelastic properties of starch-based structures will be investigated using rheological (flow and deformation) techniques. The relationships between granule size distribution and rheological properties of gelatinized starch dispersions will be determined.

9701625 Nonlinear Feature Generation Classifier for Agricultural Inspection**Casasent, D.P.; Schatzki, T.F.****Carnegie Mellon University****Department of Electrical and Computer Engineering****Pittsburgh, PA 15213****\$100,000****2 Years**

This is a collaborative research effort between ARS Albany (Dr. Thomas F. Schatzki) and Carnegie Mellon University (CMU) (Prof. David Casasent) to develop a nonlinear feature generation classifier for USDA agricultural inspection. The mission-oriented application considered is real-time X-ray inspection of pistachio nuts for feeding and insect-damage, and other minor and serious kernel damage; this is necessary to place the product in the various Federal Grade Standards. X-ray data can visualize insect infestations associated with aflatoxin, feeding damage, kernel spots, etc. that cannot be determined by present non-destructive methods. This project concerns the classifier that will analyze features and produce graded class data and defect type for each item. The classifier will produce nonlinear combinations of features to exploit higher-order correlations in the data rather than just second order statistics. A better features space thus results. The classifier will produce quadratic decision surfaces with several clusters per class to better separate data classes. ARS will provide real-time X-ray image data and food science evaluation of results. The software developed by CMU will be installed at ARS and provided to food processing manufacturers; our results will be published in agricultural journals. The nonlinear feature generation and classifier concepts are quite new and are applicable to other agricultural inspection cases with different input features. They are expected to advance image classification in general and to enhance agricultural inspection and the safety, quality and competitiveness of U.S. agricultural products.

9701476 Physical Properties and Microstructure of Gellan Gels**Tang, J.; Swanson, B.****Grant 97-35503-4369****Washington State University****Department of Biological Systems Engineering****Pullman, WA 99164-6120****\$150,000****3 Years**

Gels are used as texture modifiers in low fat or low sugar foods and can form edible coatings to reduce oil uptake of fried foods and extend the shelf life of perishable agricultural produce. Gellan is a bacterial polysaccharide approved for food use by the FDA in 1992. Gellan gels can be formed by thermal or cold setting and exhibit gelling, flavor releasing, clarity and acid tolerant properties desired in many food applications. A lack of information on the relationship between functional and structural properties of simple gellan gel systems and on the interactions between gellan and other components in complex food systems prevents full application of gellan's novel properties. We will gain a better understanding of rheological and functional properties of gellan gels as affected by gel composition, structure and, especially, temperature by using large and small deformation rheological tests and by electron microscopy studies. Including temperature as a variable in the study will allow us to investigate the thermodynamic principles governing the rheological and other functional properties of the gels so that qualitative relations may be developed to predict gel behavior in food applications. We will also investigate effects of the interaction between gellan, whey proteins, and sugars on properties of complex gel systems. The research will provide the food industry and research community information on important gellan gel properties. Gellan is a fermentation product from corn syrup, and U.S. is the exclusive gellan supplier. Increasing industrial and consumer applications of the novel gellan properties will benefit U.S. agriculture and food systems.

9701989 Evaluating Nonlinear Viscoelasticity of Wheat Flour Dough by Large Amplitude Oscillatory Shear Tests
Gunasekaran, S.; Giacomini, A.J.**Grant 97-35503-4370****University of Wisconsin, Madison****Biological Systems Engineering Department****Madison, WI 53706-0000****\$126,000****2 Years**

Rheologically, the wheat flour dough is highly nonlinear for strains $>0.1\%$. Few investigations of nonlinear viscoelasticity of dough have been reported using Instron-type uniaxial devices and/or dynamic rheometers. The strain rates obtainable in these are much smaller than what dough experiences during many real processes-mixing, kneading, baking, extruding, etc. It has been demonstrated that small and large deformation rheological properties are not necessarily related. Thus, to accurately evaluate many processing operations, rheological properties of foods should be evaluated under strain rates comparable to those actually experienced by the materials. Rapid and large amplitude deformations are also suitable for studying time-dependent structural changes in rheologically-complex materials such as dough.

We propose to study the large strain behavior of hard red winter wheat flour dough using a sliding-plate rheometer (SPR). Unlike parallel disk and sliding cylinder configurations, the SPR generates a homogeneous, simple shear flow field. We will use the SPR in the following modes: (a) large amplitude oscillatory shear (LAOS); (b) exponential shear; and (c) interrupted shear. In the LAOS mode, several strain and frequency combinations will be used to obtain a wide range of strain rates. Using the spectral analysis procedure, Fourier series components of stress amplitudes and phase shift angles will be obtained and used to determine the nature of nonlinearity of the dough. From the exponential shear tests a material function, exponential viscosity can be calculated. The extent of structural reentanglements can be evaluated from the interrupted shear test data. Three popular constitutive models will be evaluated for their validity in describing the viscoelasticity of dough. The results of this study will provide new information suitable for accurately predicting the behavior of dough during various processing conditions.

NON-FOOD CHARACTERIZATION/PROCESS/PRODUCT RESEARCH

Panel Manager - Dr. David L. Kaplan, Tufts University

Program Director - Mr. Jeffery L. Conrad

Agricultural commodities can provide the raw materials for production of numerous industrial and consumer products such as lubricants, fuels, paints, detergents, biodegradable polymers, textile fibers, fiber composites, pharmaceuticals, and various other commodity and specialty chemicals. The Non-Food Characterization/ Process/Product Research program supports research on improved methods for producing existing non-food, agriculturally-derived products and on developing new, non-food uses for agricultural commodities. Research seeks to better understand properties of agricultural materials related to their quality, value, and processing characteristics and to develop innovative products and processes for conversion of agricultural materials to non-food products.

This program also supports biofuels research directed toward understanding and overcoming factors which limit the technical and economic efficiency of production of alcohol fuels and biodiesel. Supported research focuses on the physiological, microbiological, biochemical, and genetic processes and mechanisms controlling the biological conversion of agriculturally important biomass material to alcohol fuels.

9701574 Genetic Engineering of Value-Added Traits in Cotton Fiber**Daniell, H.; Peterson, C.M.; Dute, R.R.****Grant 97-35504-4245****Auburn University****Botany and Microbiology****Auburn, AL 36849-5407****\$219,438****3 Years**

The United States generates one-fifth of the world's cotton fiber valued at about four billion dollars annually. Although consumers prefer cotton, recently man-made fibers have captured more of the textile market than cotton. In order for cotton's market share to increase, cotton fiber quality must be improved. In the past, cotton fiber quality has been improved by classical plant breeding; however, this approach is limited by species incompatibility and available traits. An alternative approach is to introduce foreign genes to confer desired traits into cotton via genetic engineering. Protein-based polymers (PBPs) are available in nature as materials with extraordinary mechanical properties, such as spider webs composed of silk threads tougher than steel and elastin, a rubber like elastic fiber found in human arteries, that typically survives for more than 70 years, undergoing repeated cycles of stretching and relaxation. The PBP made from synthetic genes, containing the sequence GVGVP, typically found in elastin, exhibits elastic moduli and temperature transition properties that enable water absorption 10 times its own weight. Therefore, introducing this PBP into cotton fiber will improve its fiber strength, ability to absorb water, thermal characteristics and dye binding properties. In this proposal, we outline procedures to genetically engineer cotton fiber with a PBP gene, GVGVP, using the following strategies: (a) develop recombinant DNA vectors for enhanced PBP expression in cotton fiber; (b) obtain transgenic plants using the transformation vectors; (c) assay transgenic expression using molecular and biochemical methods; (d) assay fiber qualities using microscopy and physical and chemical testing for standard industrial parameters and (e) analyze the genetic composition of transgenic plants.

9701695 Developing Guayule for Domestic Production of Value-Added, Hypoallergenic Latex**Estilai, A.****Grant 97-35504-5120****University of California, Riverside****Department of Botany and Plant Sciences****Riverside, CA 92521-0124****Strengthening Award****\$150,000****3 Years**

Recently, a developing crisis has brought attention to guayule, a desert plant native to Mexico and Texas, as a possible source of hypoallergenic latex. Health and medical workers have developed allergic reactions to the proteins present in *Hevea* latex, a commercial source for manufacturing latex gloves and other latex products. Guayule latex has been reported to be free from those proteins. To commercialize guayule as a safe source of latex and solid rubber, the industry will need shrubs for latex extraction and development, a seed source for establishing large-scale guayule fields, and high-latex-yielding guayule lines that can compete with *Hevea*. The goals of this project are to develop guayule lines with increased latex production, to increase the seed output of the improved lines for large-scale planting, and to investigate the genetic basis of latex production in guayule. Plants will be screened for latex content using the genetically diverse University of California *Parthenium* collection, which consists of sexual diploid and apomictic polyploid guayule germplasms, and other related species. Crosses will be made between the high- and low-latex-producing genotypes, and the advanced and backcross generations will be used to determine the inheritance of latex production. High-latex-producing genotypes will be increased, and the seed will be used to establish large acreage of guayule. Success in this project could reduce our total dependence on foreign sources of natural rubber that costs the

nation \$1 billion annually. Also, having a renewable domestic source of latex that can be produced in the semiarid lands of the southwest can reduce our dependency on ever-diminishing petroleum oil to produce synthetic elastomers.

9701537 Textile Fibers Based on Soybean Protein and Poly (vinyl alcohol)

Kumar, S.; Kotliar, A.M.; Williams, L.D.

Grant 97-35504-4263

Georgia Institute of Technology

School of Textile and Fiber Engineering

Atlanta, GA 30332-0295

\$160,000

3 Years

The aim of this project is to develop a knowledge base to provide direction for utilizing soybean plant protein for manufacturing hydrophilic textile fibers. The soybean extract will be characterized for molecular weight and composition and will also be studied for carbohydrates and lipid content. Lipids, carbohydrates and their adducts will be separated from the protein, so a more pure protein form can be used for fiber spinning. Fibers will be spun in the (a) bi-component configuration with a poly (vinyl alcohol) (PVA) sheath and a soybean protein or protein/PVA blend core, and (b) single component configuration from protein/PVA blends. The total amount of PVA in both cases will be varied from 5 to 20%. Fibers will be characterized for various physical and mechanical properties. This work is expected to provide an excellent basis for the development of a new variety of protein and protein/PVA hydrophilic fibers for textile applications. Due to the low cost of the soybean protein, these fibers would not only be environmentally friendly, (major component consisting of a renewable resource), but are also expected to be competitively priced.

9701992 Membrane Process for Oil and Zein from Corn

Cheryan, M.

Grant 97-35504-4296

University of Illinois, Urbana-Champaign

Department of Food Science & Human Nutrition

Urbana, IL 61801-4726

\$120,000

2 Years

The objective of this research is to enhance the value of corn processing co-products by developing an improved process for extracting oil from corn or co-products in a dry milling ethanol plant. A combination of solvent extraction ethanol and membrane technology will be used. The basic process may consist of (a) using in-house ethanol (e.g., produced in the dry-milling ethanol plant) to extract milled oil in dry milled corn or low value fractions from a dry mill ethanol plant (e.g., DDGS) (b) using membrane technology to separate the oil from any impurities (e.g., zein) and to separate the oil from ethanol, and (c) recycling the ethanol (after further clean-up with a membrane if necessary) for further use in the process. The process will be optimized so that traditional products are still marketable (e.g., DDGS residue and ethanol) while maximizing yield of the new products (oil and zein). A preliminary cost analysis will be performed at the end of this phase. The higher value of these co-products is expected to generate an additional \$1.5-2.1 million per year in revenue for a typical 15 million gallon per year dry mill ethanol plant. Our goal is to optimize the process to result in a 1-2 year pay-back period for the capital equipment and minimum operating costs to ensure a satisfactory rate of return.

9701500 High Value Soydiesel Fuel Additives

Suppes, G.J.; Heppert, J.A.

Grant 97-35504-4244

University of Kansas

Department of Chemical and Petroleum Engineering, Department of Chemistry

Lawrence, KS 66045-2223

\$125,000

2 Years

Soybean oil and other triglyceride feedstocks will be used to produce gram quantities of nitrates that can be used as an additive to diesel fuel. The additives, known as cetane improvers, have been reported to reduce NO_x, particulate, and hydrocarbon emissions when blended with diesel at concentrations of about 0.1%. In addition, the increased cetane numbers resulting from the addition of cetane improvers to diesel fuel are known to improve cold-start capabilities and result in smoother engine operation.

The current cetane improver market is about \$15 million per year and includes treatment of a relatively small fraction of diesel consumed in the United States. Use of cetane improvers in Europe is common practice since they have higher cetane standards -- a trend which may reach the United States as we strive for increased fuel economy.

The National Research Council reports that diesel engines are likely to have increased utilization with new generations of vehicles due to improved fuel economies over gasoline engines. The increased use of diesel fuel and increased cetane standards are expected to significantly increase the demand for cetane improvers during the next decade. Technology that allows high performance cetane improvers to be produced from soybean oil could result in significant reductions in both imported crude oil and air pollution resulting from vehicular emissions.

The research team is comprised of faculty from the Department of Chemistry and Department of Chemical and Petroleum Engineering at the University of Kansas, and is part of a larger team including marketing, facilities management, and production. This investigation will focus on synthesizing products by several different routes, testing the products, and modifying reaction conditions to improve the viability of process scale-up.

9701497 Regulation in Solventogenic *Clostridia*
Kashket, E.R.

Grant 97-35504-5143

Boston University, School of Medicine
Department of Microbiology
Boston, MA 02118-2394

\$ 190,000

3 Years

Clostridium acetobutylicum and related bacteria were used to ferment starch and sugars to produce the industrially important chemicals, butanol and acetone until the 1950s, when the biological process was replaced with petroleum-based chemical processes. To achieve cost-effective biological conversion of waste biomass, it is necessary to improve the efficiency of the microbiological process. Normally, *C. acetobutylicum* produces the desired chemicals at the end of its exponential growth phase, regulating the induction of solvent production with the initiation of development into spores, its dormant form. The proposed research deals with factors that limit solvent production. One is strain degeneration, the spontaneous loss of the capacity to produce solvents and spores, which has been a problem in the industrial use of these microorganisms. Another limiting factor is the accumulation of the toxic product butanol. We are using mutants generated by the introduction of foreign DNA (transposons) into the bacterial chromosome, which disrupts gene integrity and function. We have isolated mutants that are resistant to degeneration and others that are resistant to high concentrations of butanol, and are now using molecular biology techniques to identify and characterize the mutated genes, in order to deduce their normal function. Such new information is important for its potential in improving the microbiological conversion of waste agricultural biomass to alcohol fuels and other chemicals by an environmentally beneficial process.

9701700 Multiphase Biocatalysis Using Reversible Aphrons
Worden, R.M.; Scranton, A.B.

Grant 97-35504-4247

Michigan State University
Chemical Engineering Department
East Lansing, MI 49924-1226

\$140,000

2 Years

Biocatalysis, the use of enzymes or whole cells to carry out chemical reactions, is well-suited for processing agricultural raw materials. Biocatalysis in two-phase systems consisting of an aqueous phase containing the biocatalyst and a nonpolar, fluid phase containing the reactant is challenging because of the slow rate of reactant transfer from the nonpolar phase into the aqueous phase. The goal of this research is to develop new methods using reversible, colloidal gas aphrons (CGA) and colloidal liquid aphrons (CLA) to enhance the reactant transfer rate. The CGA are microbubbles about 50 microns in diameter surrounded by a surfactant-stabilized aqueous shell. The CLA are analogous to CGA, but are filled with a nonpolar liquid instead of gas. The use of novel, pH-reversible surfactants allows the aphrons to be formed and maintained stable during the reaction step, and then rapidly coalesced by a small change in the pH for phase separation. The objectives of the study are to synthesize a variety of reversible surfactants suitable for production of CGA and CLA, to measure the formation and stability properties of the CGA and CLA produced using these surfactants, and to demonstrate enhancement of model gas-liquid and liquid-liquid biocatalytic processes using reversible CGA and CLA. Polymeric surfactants having different molecular architectures will be synthesized, and their properties will be evaluated as a function of pH. The most promising of these surfactants will then be used in two bioconversion processes having agricultural relevance: synthesis-gas fermentations and bioconversion of limonene to terpineol.

9701519 Integrated Utilization of Agricultural Residues for Fibers and Chemicals
Chen, L.; Gratzl, J.S.; Kirkman, A.G.

Grant 97-35504-5119

North Carolina State University
Department of Wood and Paper Science
Raleigh, NC 27695-8005

\$ 105,732

2 Years

Rising demands for papermaking fibers and a limited wood supply resulted in rising costs, and thus, have generated a renewed interest in non-wood plant fibers worldwide. Restrictions on the conventional disposal of agricultural residues (e.g., wheat straw, corn stalks etc.) have reinforced the trend toward use of agrofibers for pulping in particular. Our research is designed to optimize both fiber and by-product potential for this valuable underutilized renewable resource. Most recent studies have demonstrated that by applying proper pulping technology, fibers with excellent properties for a wide range of paper and board products can be produced. The focus of our research is on environmentally friendly technologies such as (a) total chlorine and chlorine compound free - TCF - bleaching, (b) prehydrolysis of polysaccharides, mainly hemicelluloses, to simple sugars and

acids with potential applications ranging from cattle feed to raw materials for production of single cell protein (animal feed) and specialty chemicals, and finally (c) production of lignin-based agropolymers, such as slow nitrogen release fertilizers and soil conditioners. The ultimate goal of our research is to develop process design criteria and cost estimations by computer aided process simulation. All these processes have the potential of market expansion of agricultural products to meet the material needs of a rapidly rising population by optimum use of agricultural residues.

9701433 Novel Proteases for Utilization of Agricultural Co-Products

Miller, E.S.

Grant 97-35504-4264

North Carolina State University

Department of Microbiology

Raleigh, NC 27695-7615

\$60,000

2 Years

Poultry and animal rearing practices annually generate tons of protein byproducts. When efficiently processed and converted from complex proteins to amino acids, these by-products can provide a significant nutritional supplement for feeds, fermentation substrates, amino acid precursors for chemical syntheses, and other fine chemicals. Due to their uniform composition and stable structure, poultry feathers are a good substrate for value-added conversion of protein by-products and provide a model substrate for proteolytic enzymes.

The feasibility of feather degradation to value-added products was previously demonstrated using strains of the bacterium *Bacillus licheniformis*. To fully realize the potential of on-site feather processing, conduct proteolysis under a variety of fermentation conditions, and provide flexibility in industrial applications, proteases active under a variety of condition are needed. Bacteria growing under extreme conditions of temperature and pH (extremophiles) often produce enzymes that degrade complex polymers such as proteins.

One aim of this program is to isolate or engineer new proteases for converting proteinaceous wastes into value-added products under diverse reaction conditions. Specifically, we are isolating feather-degrading bacteria that grow on feathers at high or low temperatures and pH. We are also using methods of directed evolution on cloned proteases to isolate enzymes active on feather keratin under diverse conditions.

9701669 Development of Grafted Chitosan Fibrils for Absorbent End-Uses

Hudson, S.M.

Grant 97-35504-4265

North Carolina State University

Fiber and Polymer Science Program

Raleigh, NC 27695-8301

\$95,755

2 Years

Chitin, derived from shell fish waste, continues to be an under-utilized resource. Chitin is the polymer which gives the shrimp and crab shell its plastic like qualities. A more tractable form of chitin is its derivative, chitosan, which is readily solubilized. Chitin and chitosan are similar to cellulose, which is the polysaccharide found in cotton. However, chitin and chitosan are recovered as powders upon isolation from shell-fish waste. The goal of this research is to develop chitosan fibers from this powder, that would be similar in appearance to cotton. Chitosan however, differs from cellulose in a number of important ways. An example is the anti-fungal and anti-microbial properties of chitosan fibers. A second goal of this research is to modify the chitosan fiber surfaces to make them more water absorbent. This would permit these fibers to be blended with other absorbent fibers and lend their anti-microbial properties to these blends for use in baby diapers and the like. To modify the chitosan fiber surfaces, we will evaluate the use of photo-initiated vinyl grafting reactions with acrylic acid, which is the monomer used to make the so-called "super-slurper" polymers which have a very high affinity to water. The initiator system, based on metal carbonyl complexes has not been used with polysaccharides before, but should offer a number of important advantages over other systems for grafting the surface of chitosan.

9701619 Optimization of an Automated Continuous-Flow Vermicomposting Reactor

Edwards, C.A.; Subler, S.

Grant 97-35504-4298

Ohio State University

Soil Ecology Laboratory

Columbus, OH 43210-1220

\$140,000

2 Years

During the last fifteen years, various methods of processing animal and food wastes using earthworms have been developed, ranging from simple windrow systems to fully-automated systems needing few labor inputs. Such systems have produced excellent horticultural plant growth media, termed vermicomposts. Technologies developed by the P.I. and his colleagues utilize large-scale continuous-flow, fully-automated vermicomposting reactors to convert wastes rapidly into peat-like materials, rich in plant nutrients, that could have high value as commercial plant growth media. This work has three objectives: (1) to determine the effects of major process parameters (type and quality of raw materials, rates of application, and pre-processing) on agricultural

and food waste processing rates using continuous-flow automated vermicomposting reactors; (2) to assess the influence of major process parameters on earthworm population dynamics in continuous-flow automated vermicomposting reactors; and (3) to characterize the physical, chemical and biological transformation of wastes during vermicomposting, and assess the suitability of the resulting vermicomposts as high-value plant growth media. The results will provide a basis for adoption of an improved version of this innovative technology to transform agricultural and food wastes into high-value products.

9701681 Kudzu-Biodegradable Plastic Paper Products**Dever, M.****Grant 97-35504-4299****University of Tennessee****Textile, Retail and Consumer Sciences Department****\$150,000****Knoxville, TN 37996-1900****2 Years**

Kudzu (*Pueraria lobata* (Wild) Ohwi) is a perennial, climbing vine of the legume family that was brought to the southeastern United States from Japan at the turn of the century for use as a soil stabilizer, animal food, and ornamental vine. Due to its prolific nature and lack of natural insect or disease controls, kudzu quickly became a pest. Today, kudzu has spread north to Illinois and Massachusetts, west to Texas and Oklahoma, and south to Alabama, Georgia and Mississippi. It has also recently been found in Florida where it has begun to invade the Everglades. Control of kudzu is a problem. Dr. James H. Miller of the U.S. Forest Service in Auburn, Alabama has found that one herbicide actually makes kudzu grow better while many have little effect.

The purpose of the proposed research is to determine the feasibility for commercializing kudzu paper products. We will determine if kudzu can be made into paper using industrial paper machines. We will (1) investigate chemical and mechanical methods of pulping kudzu, (2) ways to improve its strength, (3) determine the structure/process/properties of a wide variety of kudzu papers, (4) generate and characterize a variety of kudzu papers, and (5) identify specific end use applications and potential markets for the kudzu paper products.

9701615 Factors Affecting Solvent Production in *Clostridium acetobutylicum***Bennett, G.N.; Rudolph, F.B.****Grant 97-35504-4246****William Marsh Rice University****Department of Biochemistry and Cell Biology****\$195,000****Houston, TX 77005-1892****3 Years**

The objective of the proposal is to increase our knowledge of the molecular processes which control and limit the production of the solvents acetone and butanol in the anaerobic bacteria *Clostridium acetobutylicum*. This organism has excellent potential for the industrial production of chemicals (e.g., butanol which mixes better with hydrocarbon fuels than ethanol), and the organism is able to grow on a variety of biomass materials. Experiments proposed at this stage are devoted to analysis and modification of the lipid components of the cell membrane. The composition of the membrane is considered a major factor in tolerance to solvents. If the strains can be adapted to be more solvent tolerant, the prospects for generating higher yielding strains are enhanced.

We also plan to develop genetically altered strains which will differ in their membrane composition and tolerance for solvents. These methods and strains developed will be useful in subsequent efforts to optimize the capability of the organism to form higher concentrations of solvent products. Through these genetic, biochemical and fermentation experiments, we will be better able to develop *C. acetobutylicum* for industrial purposes.

9701784 Enhanced Phosphorus Availability from Soybean via Phytase Gene Engineering**Grabau, E.A.; Denbow, D.M.****Grant 97-35504-4297****Virginia Polytechnic Institute and State University****Department of Plant Pathology, Physiology, and Weed Science****\$195,000****Blacksburg, VA 24061-0346****3 Years**

Phosphorus is an essential nutrient for animal growth and development. Phosphorus is plentiful in plant seeds as phytate (myo-inositol hexakisphosphate), a storage form that is largely unavailable to monogastric animals such as swine and poultry. Undigested phytate is excreted in manure, which is commonly applied as fertilizer to pastures and croplands. In areas of intensive animal agriculture, high soil phosphorus levels can contribute to environmental phosphorus pollution of lakes and streams due to run-off. Soybean meal is a major component of animal diets. Making phosphorus available in meal derived from soybean seeds should have a significant impact on nutrient and waste management in animal industry. Phytase is an enzyme that hydrolyzes phytate to release free phosphorus and myo-inositol. We will introduce a modified phytase gene into soybean tissue culture and regenerate transgenic soybean plants expressing phytase during seed development. A fungal phytase gene will be obtained from *Aspergillus niger* and inserted into transformation plasmids utilizing seed-specific promoters. The phytase protein

coding region will be modified to include known targeting sequences that will direct proper subcellular localization of the enzyme. The targeting of phytase to the site of phytate accumulation (the protein bodies) should allow a decrease in phytate levels and an increase in available phosphorus. Other antinutrient properties of phytate include the chelation of essential minerals and the formation of indigestible protein complexes. The generation of low phytate soybean seeds by this genetic engineering strategy should provide an alternative route for increasing phosphorus, mineral, and protein availability in animal diets.

9701735 Phytase from Transgenic Alfalfa for Supplementation of Poultry and Swine Rations

Straub, R.; Koegel, R.G.; Austin-Phillips, S.; Bingham, E.T.; Cook, C.E.

Grant 97-35504-4249

University of Wisconsin, Madison

Department of Biological Systems Engineering

Madison, WI 53706-1533

\$150,000

2 Years

Phytase, an enzyme allowing monogastric animals to derive otherwise unavailable phosphorus from their grain-based diets, has been produced in transgenic alfalfa by an interdisciplinary UW-ARS research team. The phytase is expressed at high concentrations, greater than 1.5% of soluble protein in the herbage of the highest producing plants, and has shown the capability of replacing the normal inorganic phosphorus supplementation in an initial poultry feeding trial. While this has economic importance, the environmental benefits are of great significance. Research reported in the literature has shown that phosphorus levels in excrement from poultry and swine fed phytase are reduced to approximately half their normal level. The overall objective of this research is to advance the technology for producing phytase in transgenic plants and for utilizing it in poultry and swine rations to the point where it can be commercialized by the private sector. Sub-objectives include: (1) selection, propagation, and production of adequate transgenic alfalfa to make possible additional feeding trials both with poultry and swine and to establish processing and storage requirements which will insure phytase activity; (2) evaluation of alternate processing pathways for converting the phytase-containing alfalfa juice to stable form(s) containing active phytase, as well as certain other valuable constituents; (3) determining, by means of feeding trials with poultry and swine, the level of phytase needed in the ration to eliminate phosphorus supplementation and to reduce phosphorus in the excrement; and (4) developing, by means of plant breeding, stable alfalfa cultivars which, in addition to high phytase expression, have good persistence and production characteristics.

9701817 High Fiber Content Composites of Agro-Fiber/Thermoplastics

Sanadi, A.R.; Caulfield, D.F.

Grant 97-35504-4248

University of Wisconsin, Madison

Department of Forestry

Madison, WI, 53706-1598

\$190,000

3 Years

Considerable interest has been generated in the potential use of agro-fibers and the use of agro-fiber wastes as fillers and reinforcements in commodity thermoplastic composites. Costly and/or dense additives, like minerals and glass fibers, can be replaced in some applications by agro-materials (flax, kenaf, bagasse, etc.) with economic and environmental advantages.

Present technologies limit fiber loading in thermoplastics to about 50% by weight of fiber. The primary objective of this research is to understand the mechanisms and to develop technologies for achieving substantially higher loading (up to 75 % or more) of agro-fiber reinforcement in thermoplastics that have good mechanical properties. In order to produce high-fiber-content composites, innovative plasticization and lubrication techniques are required that improve processability (compounding, extrusion, molding, etc.) and maintain adequate mechanical properties and reduce material cost. Research is designed to incorporate additives to reduce the energy and time required for processing polyolefins and nylons with agro-materials such as flax, kenaf, bagasse, wheat straw, etc. Various test methods will be used to evaluate the possible detrimental effects of the additives on the properties of the composites, and means to overcome the major drawbacks will be examined.

The long range prospects for sustainable, efficient use of agro-fibers and agro-fiber wastes will be greatly improved by their incorporation at high levels in low cost commodity thermoplastic composites. In the long range, we will have the advantage of efficient industrial methods coupled with the large-scale use of a renewable and sustainable agricultural material.

IMPROVED UTILIZATION OF WOOD AND WOOD FIBER

Panel Manager - Dr. Thomas E. McLain, Oregon State University

Program Director - Dr. Anne H. Datko

Improved wood utilization practices depend upon a continually advancing scientific foundation of basic research in wood properties and fundamental components of wood science. This program area supports research that addresses critical barriers to improved wood utilization and that will provide the scientific base from which new research and development can proceed. The major areas of focus include: (1) wood chemistry and biochemistry, (2) physical and mechanical properties of wood and basic wood processing technology, (3) structural wood engineering, and (4) forest engineering research. Innovative approaches to solving fundamental problems in the field of wood science and technology are encouraged.

9702479 Technology for Reducing Water Quality Impacts from Forest Road Stream Crossings

Taylor, S.E.; Yoo, K.H.; Rummer, R.B.

Grant 97-35103-4764**Auburn University****Agricultural Engineering Department****Auburn University, AL 36849-5417****\$91,500****3 Years**

Forest roads and the locations where roads cross streams are two of the most frequent sources of sediment introduction into forest streams. However, few studies have examined how sediment enters streams at the road-stream crossing. Consequently, recommendations on which type of stream crossing to use may not be based on sound scientific information. Project objectives are to: quantify and compare water quality impacts from different types of stream crossings; quantify the amount of sediment produced by road approaches at stream crossing sites; and document life-cycle costs of various types of stream crossings. Several fords, culverts, and bridges will be installed and monitored to determine the quantity of sediment introduced into streams by each crossing throughout their life cycle. Tests also will be conducted on new stream crossing alternatives such as portable bridges. The information resulting from this study will expand the database on water quality impacts and costs of different types of stream crossings. Also, when sediment production data from road approaches are compared with sediment production data from stream crossings, we can determine whether more efforts should be devoted to reducing sediment production from the crossings or from the road approaches to the crossings. This research will expand the database from which forest managers can make more rational decisions on which type of stream crossing to use when accessing our forests. More informed decisions on construction practices will lead to more sustainable forest access systems by reducing the introduction of sediment into forest streams.

9702548 Adaptive Wood Composites: Theory and Measurement

Heyliger, P.R.

Grant 97-35103-4852**Colorado State University****Department of Civil Engineering****Fort Collins, CO 80523-0000****\$62,500****2 Years**

Adaptive wood composites are structural components constructed from layers of wood and piezoelectric material. The piezoelectric layers act as both sensing and actuating elements in the wood system, allowing the motion of the component to be detected and possibly countered depending on the desired application. Adaptive structures in the past have used metals and fiber-reinforced composites as structural elements. The inherent natural advantages of wood in an adaptive composite have not yet been exploited or studied.

In this research, a combined theoretical and experimental investigation of adaptive wood composites is proposed for flat plate geometries with different edge conditions. A numerical model will be used to account for the interactions between the wood system and the piezoelectric layers. Static and dynamic measurements will also be completed. Of primary interest is the level of strain actuation to assess how much deflection or vibration displacement can be induced within the composite.

Results from the numerical model will yield predicted limitations on the order of the imposed deformations. These will be verified and compared with the experimental observations. Following determination of the level of deformation that can be induced in the plate by the active elements, overall recommendations will be given for applications, limitations, and manufacturing difficulties for these novel wood composites. The natural strength and modest elastic moduli of wood provide a rich environment for a wide variety of uses, providing more potential applications for renewable agricultural structural components.

9702121 Dimensional Stability and Durability of Oriented Strand Board
Wu, Q.

Grant 97-35103-5055

Louisiana State University Agricultural Center
School of Forestry, Wildlife and Fisheries
Baton Rouge, LA 70803

New Investigator Award
\$49,000
2 Years

Oriented strand board (OSB) is a hygroscopic product which is dimensionally unstable as moisture content changes. The dimensional change is often accompanied with permanent strength loss and sometimes product failure when exposed to high humidity conditions. The purpose of this work is to quantify the effect of the processing variables on the swelling behavior of OSB and to assess the extent of associated strength/stiffness loss. Single-layer and cross-laminated three-layer OSB panels were manufactured in the laboratory under various combinations of flake orientation, density, resin content, and, for the three-layer boards, face-to-core weight ratios. Tests will be conducted to determine flake alignment distribution, vertical density gradient, linear expansion (LE), thickness swelling (TS), bending stiffness and strength, and stress-wave modulus. Effects of the processing variables on the swelling and strength retention properties of the OSB will be examined and quantified. Using the data from the single-layer panels, a mathematical model will be developed to predict LE and TS of the three-layer, cross-laminated panels of different constructions. Through model analysis, importance of the various factors' significance in controlling the swelling behavior of the OSB will be investigated. It is expected that a successful completion of the project will lead to a fundamental understanding of the controlling mechanisms of the swelling behavior in OSB. This will allow OSB manufacturers to adjust the manufacturing process to minimize their effects.

9702043 Load-Duration Behavior of Steel Doweled Wood Connections
Bulleit, W.M.

Grant 97-35103-4897

Michigan Technological University
Department of Civil and Environmental Engineering
Houghton, MI 49931-1295

\$73,300
2 Years

Wood structures exhibit a phenomenon referred to as the load-duration effect. This phenomenon causes the strength of the wood structure to be lower for loads that act on the structure for a long time when compared to those that act on the structure for a short time. This effect must be accounted for when designing the components that make up a wood structure. Load-duration behavior of steel doweled wood connections, such as bolted and nailed joints, has been studied to only a limited extent. The assumption in design is that the load-duration behavior of connections is identical to the load-duration behavior of wood beams. The information required to confirm or modify the factors now in use to account for this phenomenon in wood connections is not available. Wood design has moved to reliability-based load and resistance factor design. This is an important advance toward the wider use of wood in engineered wood structures and requires that areas where present understanding is limited be examined. The objective of the proposed research is to develop factors to account for the load-duration effect in steel doweled connections. This will be done through the testing of steel doweled connections to determine time-to-failure information, development of a cumulative damage (CD) model for the connections, and then combination of the CD model with random load histories to determine factors appropriate for use in an allowable stress design code and suitable for use in the new load and resistance factor design code.

9702976 Role of O-Methyltransferases in Lignin Precursor Biosynthesis in Woody Species
Campbell, W.H.

Grant 97-35103-2109

Michigan Technological University
Department of Biological Sciences
Houghton, MI 49931-1295

\$110,000
2 Years

Lignin is the biopolymer coating cellulose in wood and giving it structural strength; however, the difficulty with removing lignin during pulping raises cost of paper production. Lignin is essential for viability of vascular plants but its content varies greatly in woody species. This raises possibilities for biotechnological modification of lignin content and chemistry in forest species of commercial interest. To achieve this goal, clear understanding of the biochemistry and regulation of enzymes involved in the biosynthesis of lignin precursors is required and that is the objective of this project. O-methyltransferase sits in the middle of biosynthetic pathways and controls (to a degree) lignin precursor pools and consequently the type of lignin polymer made. Recently, it was discovered that two forms of O-methyltransferase were in lignifying tissue such as xylem of woody species, where the new wood is formed each growing season. We have cloned and expressed both O-methyltransferase forms in bacteria and begun to study the biochemical properties of the enzymes. We will move the cloned enzymes to a new expression system in the methylotrophic yeast, *Pichia pastoris*, which will make enzyme production more efficient. To advance these studies we will produce large quantities of the pure enzymes and provide them to crystallographers for structural analysis. Specifically directed amino acid replacements will be made in the enzymes to gain understanding of the factors controlling lignin precursor

substrate specificity, which differs between the two enzyme forms. The results will produce the first 3-dimensional structures and detailed biochemical characteristics for plant O-methyltransferases.

9702107 Copolymer Urea-Formaldehyde Resins for Formaldehyde Release Reduction**Kim, M.G.****Grant 97-35103-5051****Mississippi State University****1997 Award \$44,691****FWRC/Forest Products Department****\$90,000****Mississippi State, MS 39762-9820****3 Years**

Urea-formaldehyde (UF) resins are being used extensively as binders for particleboard, medium density fiberboard, and hardwood plywood with excellent dry bond strengths but the binders are the cause of excessive formaldehyde emitted from the bonded wood products. Furthermore, the formaldehyde emission will be required to be lowered in the future. UF resins form bonds faster, are much lower in cost, and safer to use than other current non-formaldehyde emitting wood binders and, therefore, thorough research investigations on UF resins are necessary before any replacement is considered. The aim of this study is to evaluate several copolymer synthesis methods to reduce the formaldehyde release potential of UF resins by introducing non-formaldehyde emitting epoxypropyl and hydroxyethyl functional groups. These copolymer UF resins will have higher crosslinking and polymer chain-stabilizing capabilities to allow the amount of formaldehyde used in UF resin manufacture to be significantly reduced, resulting in decreased formaldehyde emission potential. Water resistance properties of boards will also increase due to the additional functional groups. If successful, with only a moderate increase of binder cost, this technology will help the wood products industry maintain the current high manufacturing productivity and low cost structure as well as help continue the utilization of low grade wood and wood wastes, an essential component in the sustainable development of forestry resources.

9702227 Thermographic Detection of Knots in Wood Following High-Intensity Heating**Steele, P.H.; Conners, T.E.; George, C.E.****Grant 97-35103-4698****Mississippi State University****FWRC/Forest Products Department****\$47,800****Mississippi State, MS 39762-9820****3 Years**

Automated processing of lumber requires accurate machine vision detection of defects. Because knots are the most frequently occurring defect in lumber it is particularly important that they be detected. The Charted Coupled Device (CCD) cameras currently used do not detect all lumber defects and it has been shown that this failure results in a 10 percent volume loss in furniture parts recovery. An infrared knot detection method has been developed based on the recently discovered fact that knots absorb and radiate heat at a different rate than clear wood. The reason for this differential thermal response is unknown. The infrared heating method is currently too slow for commercial application. Development of a rapid heating method is hampered by the almost complete lack of available information on the characteristics of knots. Proposers will develop the lacking information on relative knot and clear wood specific gravity, moisture content, extractives content, and fibril angle for twelve species. Two rapid heating methods, high-intensity radiant and high-power radio frequency, will be applied to the wood specimens to elicit the knot and clear wood differential thermal response. Proposers will statistically correlate knot and clear wood thermal response to the information developed on knot and clear wood characteristics. It is anticipated that the determination of the factors that cause knot and clear wood differential heating will accelerate the development of a rapid heating method. This will make detection of knots by thermography viable for commercial application.

9702595 The 3rd Tannin Conference**Hemingway, R.W.; Gross, G.G.; Yoshida, T.****Grant 97-35103-5054****USDA Forest Service****Southern Research Station****\$3,500****Asheville, NC 28802-0000****1 Year**

Plant polyphenols, also called vegetable tannins, are the second most abundant (after plant lignins) source of phenolic compounds on earth. The 3rd Tannin Conference will be held in July of 1998 to promote collaboration between chemists and biologists in an effort to improve our understanding of the biological significance and to expand opportunities for use of these plant polyphenols. The conference features lectures and poster presentations centered on the chemistry and biochemistry of plant polyphenols, their anti-oxidant, and anti-microbial properties, relationships with heart disease and cancer, ecological significance, and potential use as specialty chemicals. Funding provided by this grant will help in meeting the costs of honoring Professor Edwin Haslam, Department of Chemistry, University of Sheffield, Sheffield, United Kingdom, so he can present the plenary lecture at this conference.

9702575 Whole Structure Modeling and Analysis of Light-Frame Wood Buildings Subjected to Static and Dynamic Loads**Kasal, B.; Foliente, G.C.****Grant 97-35103-4677****North Carolina State University****Department of Wood and Paper Science****Raleigh, NC 27695-8005****\$119,000****3 Years**

This project is focused on a systems approach in the analysis of light frame wood structures subjected to natural hazard loads (wind and earthquake). The main goals are to increase our understanding of how the forces within a wood building that is loaded in the inelastic range are shared and distributed as a function of the load history, and to investigate how changes in material type and system configuration affect the global behavior and distribution of forces within the building. These will be achieved through the development and validation of an integrated set of nonlinear, nonconservative, static and dynamic models of the whole structure. These models - (a) finite element, (b) frame, and (c) lumped mass (for dynamic analysis only) - will incorporate two types of nonlinear, inelastic (hysteretic) elements. The completed models will allow consideration of partial joint degradation, pinching (slip) and partial loss of building integrity in static and dynamic analyses. The models will be used to study the effect of variables such as different building shapes, connections or materials on the response of the structure to extreme loads (parametric and sensitivity studies). The models will be useful as research and predictive or diagnostic tools. They can assist in the development and/or calibration of code requirements (e.g., development of performance-based criteria) and design procedures, assist in interpreting disaster damage survey and test data, provide helpful information to direct future experimental testing programs, and generate desired behavioral characteristics of wood construction under natural hazard loading.

9702168 Wood Properties of Pine with Genetically Modified Lignin**Sederoff, R.R.; MacKay, J.J.****Grant 97-35103-4796****North Carolina State University****Department of Forestry****Raleigh, NC 27695-8008****\$111,000****2 Years**

Lignin is a complex plant polymer that plays important structural roles and is a major constituent of wood where it often accounts for 25% to 30% of the dry weight. In chemical pulping, most of the lignin must be removed from the wood to manufacture high quality papers. We have identified a mutant loblolly pine which has greatly altered lignin composition and decreased lignin content. Several lines of evidence indicate that these modifications in lignin are due to a mutant form (allele) of the *cad* gene which encodes an enzyme of lignin biosynthesis, namely cinnamyl alcohol dehydrogenase (CAD). The modified lignin polymer contains a significantly increased proportion of the substrate of CAD enzyme and a major proportion of a new lignin subunit. The lignin of this mutant is more easily removed from the wood under certain alkaline conditions, indicating the potential for benefits in chemical pulping. The purpose of this study is to characterize in greater detail the modified composition and structure of the lignin and lignin precursors from different types of trees containing this mutant *cad* gene. We also propose to investigate lignin removal and reactivity under conditions that will provide basic information on the behavior of the mutant wood during pulping. We will explore the potential for other improvements in wood utilization with this mutant such as biopulping using fungi. Survival and growth rates of pines containing the mutant gene will also be monitored. Such information should lead to improved strategies for the directed modification of wood properties.

9702974 Moisture Transport in Paper Materials Under Dynamic Conditions**Chatterjee, S.G.****Grant 97-35504-4795****SUNY College of Environmental Science & Forestry****Faculty of Paper Science and Engineering****Syracuse, NY 13210****New Investigator/Strengthening Award****\$60,000****2 Years**

The moisture content of a paper sheet or board is a key parameter which affects its mechanical and electrical properties. There is a severe loss in the strength properties of paper with increasing moisture content which is accentuated under cyclic humidity conditions. We propose detailed experimental and theoretical investigations in (1) moisture sorption equilibria with special attention to the interior of the hysteresis region, (2) transport mechanisms of moisture through paper webs, and (3) the uptake and release of moisture under ramp and cyclic changes of the relative humidity (RH) of the external environment. In order to understand and quantify moisture changes occurring in a paper board under a changing external RH, all of the above three areas are linked to one another and have to be studied systematically.

The outcome of the research will be a coherent body of knowledge about the hysteresis observed in the equilibrium moisture content under equilibrium RH conditions and the mechanisms of moisture transport in paper under dynamic RH conditions. This will enable paper physicists to relate the effects of changing RH to the warp and dimensional stability of paperboard cartons and lead to better design of packaging materials. The research proposed here will be useful in developing consistent pre-conditioning

procedures for paper samples in paper testing laboratories and will also be applicable to the drying of wood and paper, thus leading to their better utilization.

9702975 Forming Aesthetic End-Joints Using Computer Vision**Brunner, C.C.; Reeb, J.E.; Funck, J.W.****Grant 97-35103-4825****Oregon State University****Department of Forest Products****Corvallis, OR 97331-7402****\$ 143,000****3 Years**

The decreasing availability of high quality, appearance-grade lumber has resulted in sharply higher prices for long, clear furniture and millwork stock. Conceivably, shorter clear-wood pieces could be joined into visually pleasing long lengths comparable to wide edge-glued panels, but because of end-joint strength and grain pattern considerations the manufacturing process would be significantly more complex. Straight-cut finger joints provide the necessary strength but result in a "butcher block" appearance. While such material is adequate where parts are to be painted or overlaid, it is unacceptable for most naturally finished surfaces. In the 1970's the Forest Service developed a satisfactorily strong and aesthetic end-joint made from carefully selected pieces with precisely machined and mated sinusoidal ends. Fabricating these serpentine-end-matched (SEM) joints is presently too labor intensive for commercial use, but the process could be automated using computer-controlled vision and router systems. Manufacturing SEM joints economically would provide high-quality stock from lower-grade lumber, helping to extend our wood resources while providing desired consumer products. End-joint appearance will be studied by having industry personnel evaluate computer images with digitally manipulated wood color, grain pattern, and joint shape. The influence of important visual factors will then be measured and the results incorporated into a computer model. The software will calculate appropriate joint placement and shape based on estimates of overall visual acceptability. Lastly, the computerized SEM technique will be evaluated by producing actual end-joints in ponderosa pine and red oak.

9706631 Determinants of Sapwood Quantity in Douglas-fir**Gartner, B.L.****Grant 97-35103-5052****PECASE* Awardee 1996****1997 Award: \$118,465****Oregon State University****Department of Forest Products****Corvallis, OR 97331-7402****\$182,438****3 Years**

This research investigates the structure and physiology of sapwood as a function of its location within the tree to elucidate the "design criteria" of Douglas-fir (*Pseudotsuga menziesii*) for sapwood quantity. Whether a specimen is sapwood or heartwood has a major effect on how the wood is processed and used. Previous studies suggest that trees maintain either a constant ratio of leaf area to sapwood area, or, if the sapwood has variable permeability within a tree, constant leaf area/sapwood conductance (where conductance is area times its permeability). However, our initial research in 29-year old trees, shows that permeability did indeed vary from location to location, but that neither leaf area/sapwood area nor leaf area/sapwood conductance was the same for adjacent plantations at different tree densities, nor within one tree.

It is possible that trees adjust their sapwood area for a) water transport in the summer when some of the conduits are embolized, and/or b) a constant storage capacity per leaf area. This project is designed to distinguish between the two hypotheses regarding sapwood determinants, either that sapwood quantity is determined by water transport, or by storage. We will measure volumetric storage and respiration rates, and conductance and loss of conductance due to cavitation, for trees as a function of season and the leaf area they supply. The trees will come from age and/or aridity gradients. This research will help us predict sapwood quantity of trees from different silvicultural regimes, which will be of use to processors and users of forest products, tree physiologists, and ecosystem modelers.

*Presidential Early Career Awards for Scientists and Engineers

9702576 Preparation of Interpenetrating Polymer Networks for Improved Cellulose Ester Plastics**Wilson, J.B.; Kelley, S.S.****Grant 97-35103-4798****Oregon State University****Department of Forest Products****Corvallis, OR 97331-7402****\$121,000****2 Years**

Manufacturing plastics from renewable and sustainable resources, such as cellulose esters from wood-based cellulose rather than petroleum-based plastics (which have much of the market), offers environmental and cost benefits. Cellulose esters are commonly used for a wide variety of commercial applications including plastics, films, and fibers. Their market share could be substantially increased if they could be modified to improve their mechanical properties. By capturing increased market share they would reduce consumption of petroleum-based plastics and limit emissions of greenhouse gases that occur during the

manufacture of petroleum-based plastics. Cellulose esters have the further advantage of being potentially biodegradable. It is hypothesized that the mechanical strength (e.g., stiffness and creep resistance) of cellulose esters can be dramatically improved by mixing them with a phenolic polymer and then crosslinking the phenolic polymer to create interpenetrating polymer networks. Recently, a series of phenolic-containing polymers capable of forming miscible polymer blends with cellulose esters have been identified that can accomplish this task. These miscible polymer blends retain many of the desirable properties common to cellulose ester plastics and can be used to increase the mechanical strength while reducing costs. This study will focus on developing an understanding of the type and frequency of chemical bonds that are required to improve the stiffness and creep resistance of cellulose ester plastics. In addition to improved mechanical properties, these interpenetrating polymer networks should have improved resistance to solvents and thermal stresses while retaining the clarity and impact properties that are common to cellulose ester plastics. Improving the properties of cellulose plastics will increase the utilization of these renewable, sustainable plastics and increase the value-added utilization of wood.

9702186 Molecular Aspects of Performance in Crosslinking-PVA Adhesives Bonded to Wood

Frazier, C.E.

Grant 97-35103-4674

Virginia Polytechnic Institute and State University

Department of Wood Science and Forest Products

Blacksburg, VA 24061-0323

\$150,000

2 Years

Crosslinking-polyvinyl acetate (PVA) latex adhesives are central to the secondary manufacture of thousands of forest products. Given the importance of this material, industrial manufacturers wish to learn more about the molecular basis of performance in these adhesives. This project is directed towards the characterization of two general mechanisms that contribute to the structural integrity of the adhesive when bonded to wood. The first of these is the fate of the co-monomer N-methylolacrylamide (NMA) which causes crosslinking and enhances the weather durability of the adhesive. Solution nuclear magnetic resonance (NMR) will be used to determine the distribution of NMA in and around the polymer particles of the adhesive latex. This distribution is affected by polymerization variables and has a great effect on adhesive performance. Secondly, solid-state NMR will be used to learn more about the coalescence of polymer particles as they form the latex film. The formation of the solid film gives the adhesive structural integrity. Analysis of the film morphology will help us understand how particular polymerization variables control adhesive performance.

9702088 Modeling of Transient Effects in Hot-pressing of Wood-based Composites

Kamke, A.F.; Watson, L.T.

Grant 97-35103-4697

Virginia Polytechnic Institute and State University

Department of Wood Science and Forest Products

Blacksburg, VA 24061-0503

\$161,000

3 Years

Wood-based composites manufacture is the fastest growing segment of the forest products industry. This industry has invested more than \$2 billion over the past two years in new production facilities. The manufacturing process is highly automated, but specific process parameters are developed by trial and error. This research proposes to develop a simulation model for the critical step of hot-pressing a wood-based composite, specifically, oriented strandboard (OSB). The mathematical model will be based on first principles and be robust in nature. The design of the model will incorporate end user needs such that the completed model will be implemented into the manufacturing process. The model will assist the industry in materials selection, reduction of volatile emissions, and optimization of product properties. The mathematical model will incorporate mass and energy flow equations, chemical reaction equations for the adhesive cure, and stress and strain relationships to account for the viscoelastic, cellular behavior of the wood mat during hot-pressing. The model will be three dimensional and consist of a system of time-dependent nonlinear partial differential equations. The method of collocation will be investigated for discretization of the spatial derivatives. The key feature for the implementation of the model will be the establishment of a Web server to act as a compute engine or portal to Virginia Tech's parallel computing resources. This will allow remote users and non-experts access to the model. The remote users will not require a sophisticated computer system to use the simulation model.

9702090 Characterization of Wood Features Using Multi-Sensor Information

Kline, D.E.; Connors, R.W.

Grant 97-35103-5145

Virginia Polytechnic Institute and State University

Department of Wood Science and Forest Products

Blacksburg, VA 24061-0323

\$74,000

2 Years

The use of our natural forest resources has recently become more restricted in light of old-growth timber, endangered species habitat, and bio-diversity issues. While greater restrictions are being placed on our forest resources, demand for wood products has been increasing. Therefore, it is increasingly important to find new ways to maximize the utilization of available forest

resources. While a significant amount of research and development has focused on the development of computer scanning technologies for wood inspection, there is a lack of basic methods to numerically describe wood features such as knots, stain, color, and other such visual attributes that influence the conversion of lumber into finished products. This study will focus on developing better methods to characterize wood features so that automatic detection methods can be applied more accurately and consistently.

Based on multi-sensor images attained from color, range, and x-ray scanning technologies, statistical and other numerical measures will be derived to provide a rich description of critical features that affect the value and quality of lumber. The ability of these measures to completely identify certain feature classes will be studied. Factors that influence the completeness of these measures, such as wood species and moisture content, will also be studied. These studies will lead to a better understanding of the measures needed to improve the accuracy and consistency of feature recognition methods. Such improved feature detection methods will ultimately lead to a more intelligent utilization of wood and wood fiber resources by the U.S. woodworking industries.

9702977 Diffusion of Wood Product Innovations in Residential Construction**Eastin, I.L.****Grant 97-35103-4896****University of Washington
College of Forest Resources
Seattle, WA 98195-2100****New Investigator Award
\$78,000
1 Year**

Rising softwood lumber prices, price instability, and perceived declines in softwood lumber quality have reduced the competitiveness of softwood lumber in the residential construction industry. This trend provides an opportunity for softwood lumber substitutes such as engineered wood products to increase their competitive position in the marketplace. Engineered wood products typically utilize lower quality raw material inputs (e.g., small diameter trees and lesser used timber species) to produce a high quality, high performance product. The key to developing markets for these innovative new products is to understand the factors that influence the adoption and diffusion of new construction materials within the residential construction industry. Residential contractors and builders will be surveyed to assess their perceptions of how various factors influence their decision to evaluate and incorporate engineered wood products into their construction practice. The information obtained from the survey will help: (1) determine the extent to which engineered wood products are currently utilized within the residential construction industry, (2) identify those factors that influence the adoption of engineered wood products, (3) identify those product attributes that influence the adoption of engineered wood products, and (4) develop models of the adoption and diffusion process. The results of this project will facilitate our understanding of how new products are evaluated and adopted by contractors and builders in the residential construction industry and provide a basis for maintaining the competitive position of wood-based materials *vis-à-vis* non-wood substitutes (e.g., steel studs and concrete).

9702592 Evaluation of VOC Emissions from Wood Composite Hot Pressing**Baumann, M.G.D.; Gardner, D.J.****Grant 97-35504-5142****USDA Forest Service
Forest Products Laboratory
Madison, WI 53705-2398****\$145,000
2 Years**

The emission of volatile organic compounds (VOC's) during manufacturing of wood-based products became an issue of particular concern after the 1990 Clean Air Act Amendment brought large sectors of the composite wood industry, including particleboard, medium density fiberboard, plywood, oriented strandboard, under the new regulation. Recent research has focused heavily on the emissions during drying of wood particles and flakes because this is the primary source of emissions during composite manufacture. However, it has been estimated that approximately 20% of the VOC emissions arise during pressing of composite products. Press emissions may be of particular concern because the adhesive components may be emitted during high temperature pressing.

In this study we will investigate the VOC emissions from wood and adhesives as they are subjected to thermal and pressure treatments similar to conditions used for commercial production of composite wood products. VOC emissions from pressing will be generated utilizing a laboratory-scale press equipped with an enclosed caul plate system. The VOC's will be routed from the press to a collection system which will trap the compounds. The trapped compounds will then be analyzed using gas chromatography-mass spectrometry (GC-MS). Press conditions such as temperature, moisture content, wood species, and adhesive type, will be altered to determine which conditions most affect the concentrations and types of emitted compounds. Special emphasis will be placed on determining manufacturing conditions which minimize emissions while still maintaining the physical and engineering properties necessary to meet product standards.

The results of this research will assist both state and federal regulatory agencies in accurately assessing the risks posed by wood pressing operations and will help wood manufacturers report and decrease the VOC emissions from their facilities.

9702515 Inhibition of Wood Decay Fungi by Pectin Binding Compounds
Green, F.

Grant 97-35103-4797

USDA Forest Service
Forest Products Laboratory
Madison, WI 53705-2398

\$78,000
2 Years

Fungal decay of wood in service results in billions of dollars (U.S.) of losses annually. This puts constant pressure on our national wood resource for replacement--as well as the need to import wood from foreign countries. The most commonly used wood preservative (CCA) contains a mixture of arsenic, chromium and copper--the most toxic being the arsenic component. Recently, environmental restrictions, national and international, are limiting or eliminating the use of broad spectrum biocides like CCA for wood preservation, primarily due to problems with disposal. In order to develop new environmentally benign or friendly treatments for control of wood decay fungi, it will be essential to understand the precise sequence of biochemical events which occur as wood is colonized by these fungi.

Our laboratory has described a series of early events during the fungal decay process which result in hydrolysis of wood pectin. Studies of wood pectin are relatively rare because it only makes up 1-4% of wood weight. Preliminary experiments have shown that fungal wood decay can be inhibited by chemical stains which bind irreversibly to the wood pectin (or the calcium bound to it) which prevents the pectin from being hydrolyzed or metabolized. The primary objective of this proposal is to study and evaluate these and additional pectin binding compounds to determine how and why they prevent fungi from decaying wood.

These experiments should define new and unique approaches to fungal decay prevention by treating wood with designer chemicals targeted specifically at common decay mechanisms which occur early in the decay process. These experiments should also provide additional information on a new generation of wood preservatives for the 21st century which lack the toxic heavy metals currently in use.

9702208 Development of Cell Wall Analytical Tools Based on the "DFRC" Method
Ralph, J.

Grant 97-35103-4956

USDA Agricultural Research Service
US Dairy Forage Research Center
Madison, WI 53706-1108

\$160,000
2 Years

Lignin is a polymer that plants use to bind the fibers together and confer structural rigidity to stems as well as provide other functions for the well-being of the plant. In the utilization of wood and plant materials, it is the polymer that must be removed to make paper. Its attachment to polysaccharides also limits the digestibility of plant materials by ruminants. Lignin's chemistry and biochemistry are important for the understanding of many major industrial and natural processes.

We recently developed a new analytical method based on Derivatization Followed by Reductive Cleavage (the "DFRC" method) for determining structural details of lignin. It exploits clean and selective reactions that convert lignins into a form in which they can be efficiently broken down into simple units that can be quantified. The chemistry involved allows the method to extend well beyond the originally defined analytical tool. It can offer a whole range of valuable new characterization methods for raw and processed plant materials. In particular, we hope to develop methods to distinguish free-phenolic from etherified lignin components, characterize pulping reactions, determine minor units in lignins, characterize non-traditional lignin precursors from natural mutants and genetically manipulated plants, and determine esterified components in lignins.

Achieving the goals of this plan will provide simplified, informationally rich analytical techniques that will be widely available for researchers who study plant cell wall chemistry including those elucidating changes to lignin under various chemical and biological degradation technologies. The availability of such techniques helps researchers optimize wood and fiber utilization.

9702226 Design Criteria for Notched Wood Beams
Soltis, L.

Grant 97-35504-4676

USDA Forest Service
Forest Products Laboratory
Madison, WI 53706-2398

\$75,500
1 Year

The safe and efficient use of forest products in construction requires rational design criteria that are adaptable to a building code. One type of wood structural member often used in construction is a beam with a sharp cornered end notch. Examples of this are a roof joist with a notch where it bears on a wall plate or a floor joist with a notch to accommodate electrical, mechanical, or plumbing lines. The current design criteria defined in building codes are based on an arbitrary rule of thumb concept which has no theoretical or experimental basis. The objective is to develop a better design for notched wooden beams which results in a safer and more efficient use of the wood resources. The design criteria will consist of three parts: (1) an analysis procedure to predict the fracture failure of the beam; (2) a test procedure to determine a data base of material input properties for the analysis procedure; and (3) presentation of both analysis and input properties in a format that is easily adapted to building codes.

9702039 A Fundamental Investigation of Polymer Adhesion in Cellulose Based Systems
Young, R.A.**Grant 97-35103-4675****University of Wisconsin, Madison**
Department of Forestry
Madison, WI 53706**\$152,000**
3 Years

A new genre of composite materials have been developed based on lignocellulosic fibers, referred to as biobased composites. Expansion of the range of uses could be realized with property enhancement through improved bonding and adhesion of the polar cellulosic materials and the more non-polar thermoplastics. Although considerable information is now available on methods for improvement of bonding and adhesion of cellulosic/polymeric materials, there is still a lack of information on adhesion in terms of chemisorption and factors affecting fundamental or intrinsic adhesion. It is the intention of the proposed investigation to gain a better understanding of fundamental adhesion between specific functional groups and lignocellulosic polymers, with special emphasis on the interaction of the more hydrophilic cellulosic macromolecules and synthetic thermoplastic polymers. The objectives of the proposal are therefore: to gain a fundamental understanding of the adhesion between cellulosic, modified cellulosic and synthetic polymers; to determine the effect of specific functional groups on fundamental adhesion between polymers; to evaluate prediction of adhesion properties based on atomic force microscopy (AFM); and to evaluate surface modification methods for improvement of adhesion between hydrophilic cellulosic material and thermoplastics. From this study the effect of specific functional groups on polymer adhesion will be better understood and it will be determined if AFM measurements can be used to predict polymer adhesion. Positive results from this investigation would result in increased usage of lignocellulosic materials in many types of applications and would provide a fundamental foundation to our understanding of how to improve adhesion of cellulosic polymers.

9702896 Lateral Load Behavior of Traditional Timber Frames
Schmidt, R.J.**Grant 97-35103-5053****University of Wyoming**
Department of Civil and Architectural Engineering
Laramie, WY 82071-3295**Strengthening Award**
\$79,500
2 Years

This research project focuses on the behavior of traditional timber frame structures under the effects of lateral load. Traditional timber frames rely entirely on wood joinery and wood peg connections to resist load. Current building codes and design specifications do not address the use of wood fasteners, do not adequately describe the observed failure mechanisms in these connections, and do not contain provisions for load sharing between the structural frame and its typical enclosure system. The goal of the proposed research is to develop mathematical behavior models that accurately represent the strength and stiffness of traditional timber frames. The research program will be conducted through experimental studies of joint assemblies and full-scale structural frames. Successful completion of this research is expected to expand the market for traditional timber frame structures, to improve utilization of wood resources through more efficient design, and to improve safety of the occupants of these structures.